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DIFFUSION AND DEFECT CHARACTERIZATION STUDIES OF MERCURY CADMIUM TELLURIDE

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I. PROGRESS DURING THE REPORTING PERIOD

Two major areas are under study: epitaxial film growth of $Hg_{1-x}Cd_xTe$(MCT); and diffusion in MCT. The objective of the film growth study is to evaluate mechanisms of the film growth process and to provide samples for property and device study in MCT. The objectives of the diffusion studies are to resolve inconsistences in the literature regarding this important practical phenomenon and to elucidate the dominant defects present in this ternary compound. A brief description of current activity and progress is given, below.

A. Epitaxial Growth of MCT

Exploratory experiments have been performed on three growth techniques, liquid phase electroepitaxy (LPEE), liquid phase epitaxy (LPE), and vapor phase epitaxy (VPE). The work on LPEE has been discontinued because it did not seem promising.

Work done on the LPE technique, using Te rich melts, for X=0.2 and temperatures of 500 and 550°C, has yielded results which support the work of Harman (T.C. Harman, J. Electronic Materials, Vol. 9 #6 (1980) pp. 945). Results of growth done from the Hg rich corner using a closed tilter technique generally support the previous work of Herning for growth at 500°C (P. Herning, J. Electronic Materials vol. 13 (1984) pp. 1). There are indications of a cooling rate dependence of the x value grown using Hg rich melts, with higher cooling rates giving lower x values.

Work has been performed on VPE using a novel source material consisting of ≈90% MCT of the desired x value and ≈10% LPE melt corresponding to the x value and growth temperature. This type of source fixes the chemical potentials over the source and enables us to fix the surface composition of the growing layer under certain conditions. Using these sources, a series of experiments were performed in which only one growth parameter at a time was varied. These results and available thermodynamic data enabled us to qualitatively model this process. Growth is driven by a lowering in the total free

energy of the system. Kinetically, it appears that growth is the result of two interconnected processes: movement of Te_2 from the source to the substrate in the vapor phase where it reacts with Hg and the surface to give HgTe; and interdiffusion of Hg and Cd within the growing layer. Work in this area should yield information on the interdiffusion coefficient, the Hg P-T diagram and the hardness of MCT.

Work done by Bailly et al. (J. Appl Phys. Vol. 46 (1975) #10 pp. 4244) prompted us to undertake an annealing study in the hope of obtaining information on the mercury diffusion coefficient and the width of the MCT phase field. While Bailly's results seem to be reproducible, there are indications that other unaccounted for processes are also taking place which may invalidate some of his results.

B. Diffusion Studies in MCT

The slicing polishing and chemical etching techniques for preparing MCT diffusion host have been developed. Electron Microprobe analysis has been used in studying LPE (MCT)/CdTe junction interdiffusion and the CdTe/HgTe interdiffusion. The LPE/CdTe interdiffusion results show that above a certain critical Hg vapor pressure, the surface composition of LPE can be maintained constant such that the Matano analysis can be applied, and both LPE/CdTe and CdTe/HgTe preliminary results are consistent with previous studies. Results indicate that $\tilde{D}$ (interdiffusion coefficient) is independent of component vapor pressures. Indium isotope plating and Hg isotope exchange have been developed for isotope diffusion and sample sectioning technique have been developed. A resolution of 8 μm has been achieved for the first section. In order to define the diffusion system thermodynamically, a LPE liquid - MCT solid mixture is used as reservior (called an L/S reservior). Both L/S reservior and pure Hg reservior are used to compare the results and preliminary results show that there is no difference within the experimental errors for Hg diffusion. Complex profiles, with two or three branches, are observed.

II. PLANNED ACTIVITIES FOR THE NEXT REPORTING PERIOD

Both LPE and VPE growth activities will continue with emphasis on the following: extracting interdiffusion data from VPE method; extracting P-T information from the VPE method; evaluation of layers using RBS and Hall measurements; and evaluation of interface structure using TEM. Diffusion studies will continue with emphasis on tracer diffusion and the comparison of a pure Hg source and an LPE source.

III. No major items of equipment were acquired in the reporting period.

IV. There are no changes in the key personnel in the reporting period; Professor D. A. Stevenson is the Principal Investigator and James Fleming and Mei Tang are Ph.D. candidate graduate students.

V. D. A. Stevenson and J. Fleming attended and participated in the recent DARPA program review on Focal Plane Array Materials and Processing.

VI. PROBLEMS AND AREAS OF CONCERN

Obtaining appropriate materials for substrates for growth and for MCT diffusion hosts continues to be a problem. Our industrial contacts (Ford Aerospace, Texas Instruments, Rockwell) are very cooperative, but understandably are limited to the materials readily accessible to them. We have found it appropriate to purchase diffusion hosts from Cominco, thus increasing our anticipated expenditures for expendable materials.

We are developing some concern regarding the length of time of the original program (2 years) in relation to, the time required to finish our proposed work and the time necessary for the two students on the program to complete their requirements for the Ph.D. We will monitor this question carefully in the next quarter.